REMARKS

Claims 6, 7, 13, 15, 17-28, and 30-37 have been amended. Claims 1-38 therefore are pending and presented for review.[1] Favorable reconsideration and allowance are requested in light of the foregoing amendments and the remarks which follow.

1. Objections as to Form

On pages 2-4 of the Office Action, the Examiner notes minor informalities in the drawings, specification, and claims. All of the noted errors and informalities, as well as other minor informalities noted upon a review of the application, have been addressed without narrowing the claims, thereby removing these objections.

2. Double Patenting Rejection

On pages 5-8, the Examiner rejects claims 1-4 and 9-13 under the judicially created doctrine of obviousness type double patenting as being unpatentable over claims 1, 3-6, and 12-15 of U.S. Patent No. 6,598,584, of which this application is a continuation-in-part. Attached hereto is a terminal disclaimer, the submission of which is believed to remove this rejection. Submission of this terminal disclaimer does not constitute acquiescence to the merits of the Examiner's rejection.

[1] The claims as presented are renumbered per the Examiner's statements on page 2, paragraphs 1 and 2 of the Office Action. Claims as thus renumbered by the Examiner and otherwise unamended herein are characterized as "previously presented" in the Listing of Claims portion of this response.

Amendments to the Drawings:

Attachment: Annotated sheet labeled 17 and a replacement sheet labeled 17.

3. Prior Art Rejections

Claims 29 and 30 stand rejected under 35 USC §103 as being unpatentable over Hiltner in view of Haldeman. Claims 32 and 34 additionally stand rejected under 35 USC §103 as being unpatentable over Hiltner in view of Haldeman, and further in view of Talbert. These rejections are respectfully traversed.

a. Recapitulation of the Invention[2]

By way of explanation, the relevant portion of the invention relates to an improved method for achieving homogenous charge compression ignition (HCCI) in a liquid fueled engine, such as a diesel engine. HCCI has many benefits over conventional ignition because it has no throttling losses. Hence, combustion occurs simultaneously throughout the cylinder rather than as a flame front.

Much work has been done to optimize HCCI ignition in a conventional dual fuel engine, i.e., one having a gaseous fuel such as natural gas as a primary fuel and a liquid fuel such as diesel fuel as a pilot fuel. HCCI is relatively easy to achieve if the primary fuel is provided in a gaseous form because a gaseous fuel has a different autoignition temperature than the pilot fuel. On the other hand, little work has been done to date in *liquid* fueled HCCI engines because, *inter alia*, it is difficult to introduce the primary fuel in a vapor state and to homogenously mix it with air.

[2] This section 3(a) is presented for background purposes so the Examiner may understand the state of the art and, in general terms, the applicant's contribution thereto. It is not intended to constitute a specific traversal of any particular rejection. That task instead is performed in Section 3(b) below.

The inventors have solved this problem in a relatively simple and effective manner by introducing the primary fuel engine in the form of finely atomized liquid droplets having a diameter of less than about 50 microns and, more preferably, less than about 30 microns. The resulting small liquid droplets mix rapidly with the air stream when it is injected into the air intake system of the HCCI engine so as to form a homogonous charge. Specifically, the injected fuel enters the intake stream as a finely atomized mist formed from millions of micron sized droplets and rapidly vaporizes to form a homogonous mixture of the intake air. The homogonous mixture is not only well-suited for HCCI combustion but can also increase the turbo boost of air mass if the fuel is injected into the air intake system upstream of a turbo charger compressor inlet. Droplet evaporation also provides air charge cooling, reducing the load on the engine's aftercooler, if present.

The atomized droplets can be produced using a so-called MeeFog® nozzle traditionally used to supply cooling water to a gas turbine. Referring to Fig 18 by way of example, one system configured in this manner uses a Meefog nozzle 532 to inject a liquid fuel into the engine's air intake manifold 434. The micron-sized droplets of liquid fuel are then mixed with incoming air and drawn into the combustion chamber 418 through the cylinder's air intake passage 426. The mixture is then pilot ignited through HCCI with the aid of pilot fuel injected directly into the combustion chamber 418 via an injector 432.

b. Traversal of Rejection

With respect to claim 29, the Examiner contends that Hiltner discloses all that is claimed except for the production of atomized droplets of fuel having a diameter of less than 50 microns and that it would have been obvious, in view of the teachings of Haldeman, to replace Hiltner's primary fuel source with one providing atomized fuel in the droplet diameter claimed. This rejection is improper because there is no motivation to combine the prior art to produce the claimed invention.

Specifically, claim 29 recites, *inter alia*, injecting a *liquid* fuel into an air stream so as to form a homogonous mixture of air and atomized droplets of fuel having a mean diameter of less than 50 microns, admitting the mixture into a combustion chamber of an IC engine, and then igniting the fuel by compression ignition so as to achieve HCCI. None of these steps is disclosed or suggested by the prior art relied upon by the Examiner.

The cited Hiltner patent discloses HCCI, but *not* of a liquid fuel having the claimed characteristics. The passage cited by the Examiner simply briefly describes HCCI in general:

> An *evaporated* liquid or gaseous fuel is mixed with air before or shortly after the air is provided at the cylinder to perform a homogonous charge.

Col. 2, lines 21-28. However, Hiltner never discloses or even hints that the main or primary fuel charge should or even could be supplied to an incoming airstream in the form of a finely atomized liquid. All embodiments of Hilter instead focus on the HCCI of a primary charge of a low cetane fuel with the aid of a charge of high cetane fuel. Two of

the three examples disclosed in the Hiltner patent focus on a dual fuel engine having a *gaseous* fuel as the primary, low cetane fuel charge. In the embodiment of Fig. 1, the low cetane gaseous fuel is supplied to a fuel inlet valve 22 from a source 40 via a gaseous fuel stream 42. A high cetane pilot liquid fuel is also supplied to the same stream 42 from a source 44. Col. 6, lines 37-49. A combustion airstream 33 is supplied to the cylinder via a separate intake port via an air intake manifold 32. Col. 6, lines 14-23. In the embodiment of Fig. 2, a low cetane gaseous fuel 102 is supplied to the air intake stream 33 via a source 122, and a high cetane liquid fuel is injected directly into the cylinder 15 via a separate fuel injector 101. See col. 8, lines 11-29. In the embodiment of Fig. 3, both a high cetane fuel and a low cetane fuel are supplied to the air intake manifold 32 via respective sources 210 and 211. Col. 8, line 5 through col. 9, line 53. Although Hiltner states that the low cetane fuel of the third embodiment is not necessarily a gas, Hiltner never specifically discloses any particular liquid fuel composition or characteristic for the primary fuel charge. It certainly never hints that a liquid fuel should be provided in the form of fine atomized droplets.

Haldeman cannot cure the deficiencies of Hiltner. It instead discloses a height specialized injector for injecting a super critical water/fuel composition into an engine. The injector clearly is configured to inject fuel *directly* into the combustion chamber rather than into an intake airstream as claimed, as evidenced by, e.g., the following passage from the Background section:

> Engine manufacturers are going to higher tolerances on the piston--wall machining to reduce engine oil burning. Additionally, they are moving to higher and higher injection pressures. ***The higher pressures result in better spray penetration into the combustion zone*** as well as finer droplet sizes. The higher pressures permit smaller orifices at the injector tips while still maintaining the same mass flow rate.

Col. 1, lines 18-24. The emphasized passage clearly indicates that the fuel is to be injected directly into the combustion chamber, as injection into an incoming airstream would have no effect on spray penetration into the combustion zone. There is no suggestion whatsoever anywhere in Haldeman that its injector is suitable for injecting fuel into an incoming airstream of an HCCI engine system or that the disclosed supercritical water/fuel composition is suitable for combustion by HCCI. To the contrary, a rather extensive list of possible applications for the disclosed injector makes no mention of HCCI engines. See, e.g., col. 6, line 66 through col. 7, line 19. As such, applicants submit that the purported motivation to combine the references comes from an improper hindsight reconstruction of applicants' invention, gleaned from nothing more than applicants' disclosure.

In addition, Haldeman states that the supercritical mixing of liquid fuel and water achieved by its injector ***raises*** the effective cetane number of the injected fuel. Col. 3, lines 43-50. Haldeman therefore teaches directly *away* from replacing any of Hiltner's primary or *low cetane* fuel sources with Haldeman's injector. The rejection of claims 29 and 30 therefore is improper and should be withdrawn.

The rejection of claims 32 and 34 is traversed because nothing in Talbert cures the above-described deficiencies of Hiltner and Haldeman. Talbert merely discloses that it is known to use a fogging nozzle 99 of a particular type to provide atomized fuel in a *carbureted* or Otto auto cycle engine fueled by gasoline or the like. Col. 1, lines 18+. There is no indication that this particular fogging nozzle would produce liquid droplets of the claimed size. Nor is there any suggestion whatsoever that the particular nozzle and associated fuel source of Talbert is suitable for supplying liquid fuel for HCCI combustion. There is certainly no indication that its nozzle is suitable for use in Hiltner's particular system. Withdrawal of the rejection of claims 32 and 34 is believed to be in order and is respectfully requested.

4. Allowable Subject Matter and Conclusions

The indication of the allowability of claims 21-28 and of the presence of allowable subject matter in claims 5-8, 14-27, 31, 33, and 35-37 is noted with appreciation. By this amendment, each of claims 31, 33, and 35 has been rewritten in independent form to include the limitations of claim 29 from which it depends. Because the remaining rejections have been overcome and/or are traversed for the reasons discussed above, all claims are now believed to be in *prima facie* condition for allowance. Withdrawal of all rejections and allowance of the application therefore are believed to be in order and are respectfully requested. Should there be any remaining questions the attending to of which would help expedite such matters, the Examiner is requested to contact the undersigned at the telephone number appearing below.

A check in the amount of $258 in payment of the fee associated with three additional independent claims in excess of three. No additional fee is believed to be payable with this communication. Nevertheless, should the Examiner consider any other fees to be payable in conjunction with this or any future communication, the Director is authorized to direct payment of such fees, or credit any overpayment to Deposit Account No. 50-1170.

Respectfully submitted,

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